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(54) WIDE BAND SPLITTER

(71) We, PYE LIMITED of St. Andrews Road, Cambridge, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to line splitting devices whereby signals carried by a first transmission line may be coupled into two further transmission lines in such a manner that the components of the signals appearing on each of the said further transmission lines have the same relative frequencies and amplitudes as do the components of the signals on the first transmission line, and that the signals appearing on each of the further transmission lines are equal in amplitude one with another. Such devices also provide a degree of isolation between said further transmission lines.

In particular the invention relates to a two-way splitter effective for high frequency signals in the V.H.F. and U.H.F. bands of frequencies.

A theoretical lossless passive network employed as a two way splitter to couple signals from an input transmission line equally into each of two output transmission lines would produce a signal power in each of the output lines of -3dB relative to the input signal.

If a resistive network is employed as a two-way splitter, the minimum losses occurring in the network are such that the signal power in each of the output lines cannot exceed -6dB relative to the input signal.

With an inductive splitter, network losses can be minimised so that the signal power in each output approaches the theoretical level of -3dB relative to the input signal.

A known form of two-way inductive splitter comprises a ferrite core having first and second parallel apertures. A first conductor extends from a first input terminal through the first aperture, then through the second aperture in the reverse direction to a first output terminal. A second conductor extends from the input terminal through the second aperture, then through the first aperture in the reverse direction to a second output terminal.

The input terminal may for example be a co-axial socket to receive a coaxial input cable, and the first and second output terminals may be two further coaxial sockets to receive two coaxial output cables, the input cable and the two output cables comprising respectively the first transmission line and the further transmission lines referred to above.

Inductive splitters of the type described have been employed successfully at relatively low frequencies, up to and including the V.H.F. band of frequencies, for example in distribution networks for band I television signals.

At higher frequencies, it has been found that such splitters exhibit progressively increasing losses, increasing standing wave ratio (i.e. mismatch between the input line and the splitter and between the splitter and the output lines), reduced isolation between output terminals, and unbalance of the two output signals.

The manner in which these effects arise may be more clearly understood from a consideration of the following description with reference to Figure 1 of the accompanying drawings, of a typical known inductive splitter.

Referring now to Figure 1, a ferrite core 1 having parallel cylindrical apertures 2 and 3 is mounted on a printed circuit board 4, e.g. by securing it to the board by a suitable adhesive 5.

An input coaxial socket is mounted on the side of the board opposite to core 1 so that its inner connector 6 extends through the board adjacent one end of the core and equidistant apertures 2 and 3. Output coaxial sockets 7 and 8 are mounted adjacent the same end of core 1 as is socket 6, disposed one to either side of core 1.

An insulated conductor 9, e.g. an enamel-

insulated copper wire, has one end connected to socket 6, extends through aperture 2, thence through aperture 3 and then has its other end connected to socket 8. A similar conductor 10 is connected to socket 6, extends through aperture 3, thence through aperture 2 and is connected to socket 7. Preferably those portions of conductors 9 and 10 between socket 6 and the points at which they enter respectively apertures 2 and 3 are twisted together.

In order to provide equal division of the input signal between the two outputs, with minimum losses and maximum isolation between the output terminals, it is necessary that an inductive splitter be symmetrical, with minimum stray inductance and capacitance, both to ground and between conductors.

In the arrangement described with reference to Figure 1 there may be departures from strict symmetry due to faulty positioning of the core with respect to the sockets and failure to position the conductors 9 and 10 in corresponding portions. The portions of conductors 9 and 10 outside the core constitute inductors in series with the input and with the two outputs of the device. The capacitive coupling between conductors 9 and 10 depends on the spacing S between these conductors, which is not rigidly controlled and may vary from point to point. The spacing of conductors 9 and 10 from the printed circuit board determines the capacity of these conductors to ground, and is not necessarily the same for both conductors.

The effect of series inductance is to introduce attenuation and thus to increase the losses of the splitter. Stray capacities affect the balance and the isolation between outputs.

At relatively low frequencies the effects of stray inductance and capacitance and the lack of symmetry are small, and the performance of the splitter approaches that theoretically possible. As the signal frequency increases, the said effects become proportionally greater, leading to increased losses, lack of balance and reduced isolation between outputs.

It is an object of the present invention to provide an inductive two way splitter capable of operation in both the V.H.F. and U.H.F. bands, and of a method of constructing such a splitter.

The present invention provides a high frequency line splitter comprising a printed circuit board provided with slots therein to accept a two aperture ferrite core, a portion of the board extending through each of the apertures of the core, the conductors threading the apertures being formed by printed circuit members present on the opposite faces of the extended portions of the board.

A first link may be provided to connect the printed circuit members at a point external to the core on one face of the extended portions of the board whilst a second link may be provided to connect the printed circuit members at the external point on the other face of the extended portions of the board. The ends of the printed circuit members remote from the links may be connected by additional printed circuit members to input and output terminals such that a first conductive path is provided from an input terminal through both apertures of the core to a first output terminal and a second conductive path is provided from the input terminal through both apertures of the core to a second output terminal. At least one of the additional printed circuit members may form a transmission line matched to the impedance of the input or output terminal with which it is associated.

According to a further feature of the invention, a resistor and a capacitor are connected in series between the said first and second links to provide improved matching and improved isolation between the ouput terminals at high frequencies.

The above and other features of the invention will be more clearly understood from a consideration of one embodiment of the invention which is described, by way of example, with reference to Figures 2 and 3 of the accompanying drawings, of which:—

Figure 2 illustrates a portion of a printed circuit board for use in an inductance splitter according to the present invention; and

Figure 3 is a perspective sketch of an inductive splitter according to the invention assembled on the board of Figure 2.

Referring first to Figure 2, a portion of the upper surface of a double-sided printed circuit board 21 is shown in Figure 2a, whilst the corresponding portion of the lower surface is shown in Figure 2b. Three slots 22, 23 and 24 are provided which extend from the edge of the board 21, leaving a member or tongue 25 between slots 22 and 23, and a similar member 26 between slots 23 and 24. The slots are positioned and dimensioned so as to accept a two aperture ferrite core, with members 25 and 26 extending one through each aperture of the core in the manner shown in Figure 3.

A hole 27 which accepts the centre connector of a coaxial input socket is provided in line with the axis of slot 23. On the upper surface of the board, a copper conductor 28 extends from around the hole 27 along the member 26. A hole 29 is provided in conductor 28, also on the axis of slot 23. On the lower side of the board, a conductor 30 extends from around hole 29 along the member 25. The hole 29 may be through plated, or alternatively a pin may be inserted and soldered to conductors 28 and 30 to establish connection between these conductors through the board.

A hole 31 to accept the centre connector of a first coaxial output socket is provided adja-

cent the inner end of slot 22. On the upper side of board 21, a conductor 32 extends from around hole 31 along the member 25.

A hole 33 to accept the centre connector of a second coaxial output socket is provided adjacent the inner end of slot 24, in a position of symmetry with the position of hole 31 whilst a further hole 34 is provided on the axis of slot 24. On the upper surface of the board 21 a conductor 35 extends from hole 33 to hole 34. On the lower surface of the board, a conductor 36 extends from hole 34 along member 26. Hole 34 may be through-plated or provided with a pin soldered to establish connection between the conductors 35 and 36.

On the lower side of board 21, an area of copper 37 surrounds holes 27, 31 and 33; a circular space clear of copper being provided immediately surrounding each of the said holes in order that the centre connectors of coaxial sockets inserted in the holes shall not contact copper sheet 37. The outer shells of the sockets are soldered to copper sheet 37, which serves as a ground plane, while the centre connectors 6, 7, and 8 of coaxial sockets (Figure 3) are soldered respectively to conductors 28, 32 and 35.

Turning now to Figure 3, a ferrite core 1 is placed in the slots with member 25 projecting through aperture 2 and member 26 projecting through aperture 3. The thickness of the board and the dimensions of the slots are chosen, having regard to the diameters of apertures 2 and 3 and the overall dimensions of core 1, so that the core is positively located laterally and vertically.

A conductive link 38 is positioned adjacent the end of core 1 and soldered to conductors 28 and 32 whilst a similar link 39 is soldered to conductors 30 and 46. The links 38 and 39, in addition to joining conductors 28 and 32 and conductors 30 and 36 respectively, also serve to locate core 1 in the longitudinal direction.

It will be seen that a first conductive path has been established from input coaxial socket 6, via conductor 28, link 38, and conductor 32 to output socket 7, and that a second conductive path has been established from input socket 6 via conductor 28, hole 29, conductor 30, link 39, conductor 36, hole 34 and conductor 35 to an output socket 6. These first and second paths traverse the apertures of core 1 in opposite directions and correspond to the conductors 9 and 10 of Figure 1. The paths are rigidly located and symmetrically disposed with respect to the core so that good balance of the outputs is secured. The capacitive coupling between the paths, is dependent on the dielectric constant of the board and on the areas of superposed conductors, e.g. 30 and 32, and therefore remains constant.

In the embodiment illustrated in Figures 2 and 3, the input and output sockets are mounted close to the core to minimise the lengths of conductor external to the core, and hence to minimise the stray inductances and capacitances associated with these portions of conductors. However, any or all of the said sockets may be removed to a greater distance from the core without any increase in stray impedances provided that connection between the socket(s) and the splitter proper is made via a matched transmission line. For example, the input socket 6 may be removed to a greater distance from the core, conductor 28 being extended to suit. The portion of conductor 28 overlying ground plane 37 will form a transmission line, which may be matched to the impedance of the input cable by suitable choice of width, having regard to the thickness and dielectric constant of the board material.

In cases where the source of the signals fed to the splitter is mounted on the same printed circuit board as the splitter, the input socket 6 and input cable may be omitted, the input signal being carried from source to splitter by a transmission line as described above. Similarly, if either of both of the loads to be supplied by the splitter are carried on the printed circuit board, the corresponding output socket(s) may be omitted and the splitter output(s) connected to the load(s) through matched transmission line(s).

An inductive splitter of the form so far described with reference to Figure 2 and 3 will give satisfactory operation at frequencies in the U.H.F. band, although with some increase of standing wave ratio and reduction in isolation between outputs as the upper limit of the band is approached.

A further improvement can be secured by connecting a compensating network comprising a resistor and capacitor in series between the two conducting paths, as illustrated in Figure 3. One connecting lead from a resistor 40 is soldered to conductors 32, and 28, so that in this instance the lead forms link 38 whilst one connecting lead from a capacitor 41 is soldered to conductors 30 and 36 to form link 39. The second connecting lead from resistor 40 is soldered to one end of a pin 42 inserted in a hole 43 in board 21 and the second connecting lead from capacitor 41 is soldered to the other end of pin 42.

A two-way conductor splitter constructed according to the invention and in which the core 1 was a Mullard ferrite core Type FX2049, the value of resistor 40 was 75 ohms and the value of capacitor 41 was 8 picofarads gave the following results:—

Frequency	Attenuation		Isolation 1 — 2
	Output 1	Output 2	
200MHz	3.5dB	3.5dB	26dB
500MHz	3.5dB	3.5dB	26dB
800MHz	3.5dB	3.5dB	22dB

From the above table it is seen that the splitter gave a balanced output, with losses not more than 0.5dB greater than the theoretical minimum, and with isolation between outputs greater than 20dB for frequencies up to at least 800 MHz.

WHAT WE CLAIM IS:—

1. A high frequency line splitter comprising a printed circuit board provided with slots therein to accept a two aperture ferrite core, a portion of said board extending through each of the apertures of said core, the conductors threading the apertures being formed by printed circuit members present on the opposite faces of said extended portions of said board.

2. A high-frequency line splitter as claimed in Claim 1 in which a first link is provided to connect the printed circuit members at a point external to said core on one face of said extended portions of said board whilst a second link is provided to connect the printed circuit members of said external point on the other face of said extended portions of said board.

3. A high frequency line splitter as claimed in Claim 2 in which the ends of said printed circuit members remote from said links are connected by additional printed circuit members to input and output terminals such that a first conductive path is provided from an input terminal through both apertures of said core to a first output terminal and a second conductive path is provided from said input terminal through both apertures of said core to a second terminal.

4. A high frequency line splitter as claimed in Claim 3, in which at least one of said additional printed circuit members forms a transmission line matched to the impedance of the input or output terminal with which it is associated.

5. A high frequency line splitter as claimed in Claim 2, 3 or 4 in which a resistor and capacitor are connected in series between said first and second links.

6. A high frequency line splitter substantially as herein described with reference to Figures 2 and 3 of the accompanying drawings.

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FIG. 1.

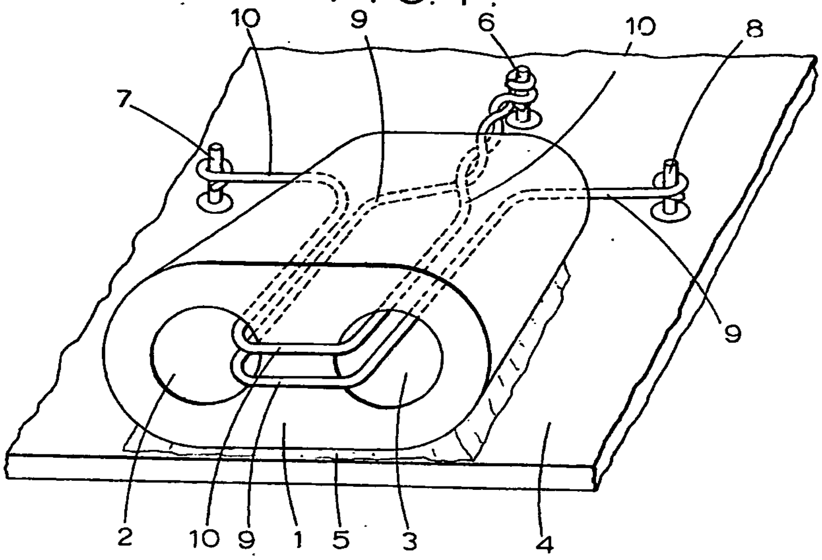
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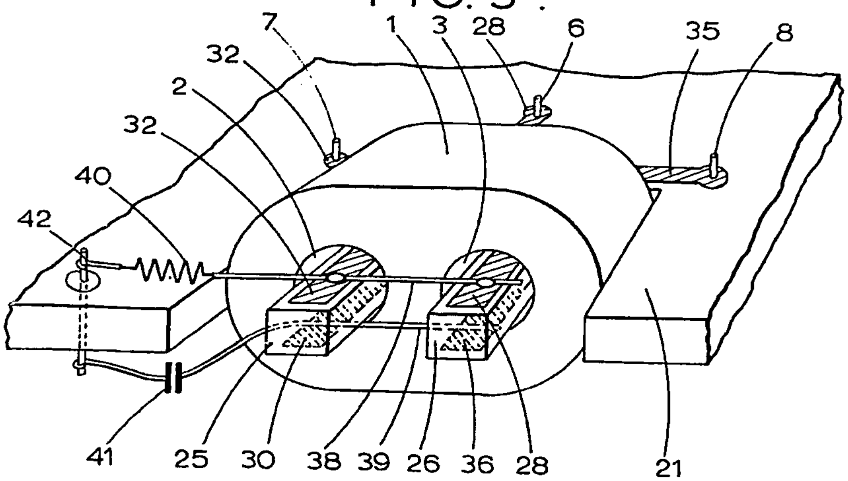
FIG. 3.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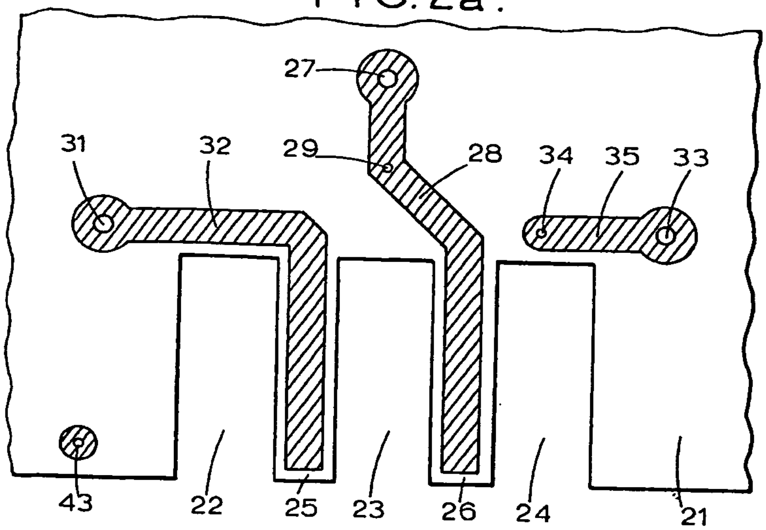
1249823 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

FIG. 2a.



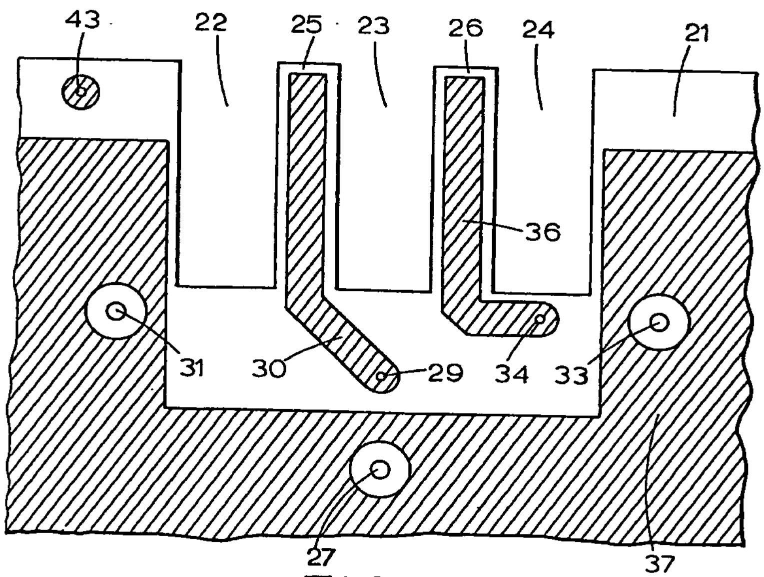


FIG. 2b.